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THE ORBITING OBSERVATORIES

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The Orbiting Observatories are a family of medium size earth satellites being ~~designed~~ developed by the National Aeronautics and Space Administration, Goddard Space Flight Center to assist in the study of the space sciences. They consist of basic spacecraft structures, the servicing subsystems, and the experiments. The observatory concept includes the development of standard structures and sets of subsystems which can be used repeatedly with many different sets of scientific experiments in orbits chosen to meet the needs of these experiments. It also includes the development of checkout equipment, receiving stations, tracking systems, data processing equipment, and the various techniques for providing the experimental data to the scientists as rapidly and efficiently as possible for their analysis.

Inherent in the observatory concept is the inclusion of well defined and flexible mechanical, thermal, and electrical interfaces between the spacecraft (structure plus operating subsystems) and the experiments. Thus, it is possible to accommodate many different types of scientific and technological experiments prepared by investigators located throughout the country, without the need to design a new spacecraft for each new mission.

The standard spacecraft consists of the following five individual subsystems:

1. The basic structure within which the assemblies of the other subsystems and experiments are mounted.
2. An ~~altitude~~ attitude control subsystem for orienting the observatory according to the needs of the experimenters.
3. A thermal control subsystem to maintain the temperatures of the experiments and other assemblies within a desired operating range.
4. A power supply for the experiments and other subsystems.
5. A communications and data handling subsystem to provide a degree of control of the observatory from the ground through a radio command link, to condition and store experimental and spacecraft operational data, and to transmit these data to the ground.

The advantages inherent in the concept of the standardized orbiting observatory are summarized as follows:

1. Capability of accommodating relatively large numbers of directly and indirectly related experiments on each mission for concurrently investigating the correlations between different phenomena occurring at the same points in space. For example, it will be possible to study simultaneously the relationships between solar events, the solar plasma, the earth's radiation belt structure, aurorae, and the earth's atmospheric structure.

2. Convenience to the experimenters in designing his instrumentation by providing well-defined interfaces between the spacecraft subsystems and the experiments, thereby permitting the integration of his experiments with a minimum of effort.
3. Improved operational efficiency through the continued evolution and use of a ground station network, operating procedures, and data processing equipment and techniques.
4. Improved reliability due to the repeated use and constant step-wise improvement of a basic spacecraft design in follow-on missions.
5. Reduced cost of follow-on missions, on an experiment cost per pound basis, since development of a new spacecraft for each mission is avoided.
6. Possibility of inclusion of a small number of relatively "high risk" experiments which may be purely exploratory in nature or which may be installed late in the program. The somewhat smaller probability of a positive return is acceptable in view of the fact that they will represent only a small fraction of the total experiment load.

Three types of Orbiting Observatories are presently being developed by NASA to meet the needs of its scientific research program, the Orbiting Solar Observatory (OSO), the Orbiting Geophysical Observatory (OGO), and the Orbiting Astronomical Observatory (OAO). The most significant difference between the observatories is in the characteristics of the altitude control systems.

The Orbiting Solar Observatories

The OSO (Fig. 1), as its name implies, is designed to study the Rework → sun and phenomena directly related to those on the sun; thus, its primary orientation is toward the sun. The total weight is about 210 ~~200~~ kgm including the experiments. It consists of a flywheel-like main body with attached arms, which is spun at a rate of 30 rpm to produce a large moment of inertia and a solar oriented section containing the directional sensors and solar power source. A compressed gas jet system maintains the spin rate and keeps the spin axis directed approximately perpendicular to the observatory-sun line. A motor rotates the solar oriented section relative to the main body section at the rate of main body rotation, but in the opposite direction, so that the solar oriented section always points toward the sun. The orientation of the pointed experiments relative to the sun is maintained with an accuracy better than a few minutes of arc.

The OSO power system, as on the other observatories, employs silicon solar cells and a chemical battery to assist in regulating the voltage and to provide power when the observatory is eclipsed. The data handling system contains a tape recorder for storage of data from a complete orbit. Thus, recovery of data obtained from all positions in orbit is possible on a continuous basis with a small number of receiving stations.

The first OSO was successfully placed into orbit on March 7, 1962 from Cape Canaveral by a Thor-Delta launch vehicle. The orbit had a 33 degree inclination and About 580 ~~400~~ km altitude. It operated perfectly until 360 SM
May 16, 1962, when its tape recorders failed. Real time data recovery was possible on into June, when radiation darkening of sensor optics caused improper operation of the attitude control system. The experiments performed in OSO-1 included investigations of the X-ray spectrum from 1 to 400 A, the gamma ray spectrum from 0.02 to 3 Mev and above 100 Mev, the hydrogen Lyman α line, neutrons, protons, electrons, micrometeorites, and the emissivity stability of surfaces in a vacuum environment. More Solar Observatories are scheduled. In addition, an advanced OSO is being developed in which the experiments will be able to scan the solar disc, in addition to pointing toward its center as in OSO-1.

The Orbiting Geophysical Observatories

The primary orientation of the OGO (Fig. 2) is toward the earth but it also directs sensors toward the sun and in the plane of the orbit. A number of booms are included to permit the location of sensitive experiment detectors away from the disturbing influence of the spacecraft. The total weight of the OGO is about 450 kgm, including 68 kgm for the experiments. The length of the main body is approximately 1.7 m, while the overall tip-to-tip length is 16 m. Torques for Attitude ~~altitude~~ control are provided by reaction wheels and gas jets. Horizon scanners, sun sensors, and rate gyros sense the errors and control the torques.

The OGO data system is capable of processing and transmitting analog and digital data at rates up to 64,000 binary bits per second. On board tape recorders are capable of storing at a rate of 1000 bits per second for 24 hours. The power system provides 50 watts average power for the experiments in addition to that required for operation of the spacecraft subsystems.

A wide variety of experiments will be carried by the OGO, including those designed to investigate energetic particles, magnetic and electric fields, dust, atmospheric structure, the ionosphere, meteorology, solar physics, astronomy, and space technology. A variety of orbits are possible. The first observatory (the Eccentric Orbiting Geophysical Observatory, EGO) will be launched in 1963 by an Atlas-Agena rocket from Cape Canaveral into a highly eccentric orbit extending from ~~270~~ 280 km at perigee to 110,000 km (17 earth radii) at apogee and having an inclination of 33 degrees. The second (the Polar Orbiting Geophysical Observatory (POGO) will be launched the following year from California by a Thor-Agena vehicle into a polar orbit having perigee and apogee heights of about ~~270~~ 260 km and 925 km respectively.

<u>The Orbiting Astronomical Observatories</u>

A drawing of the OAO is shown in Figure 3. It contains a very precise celestial attitude control system capable of pointing the observatory with its telescopes and other sensors toward a point on the celestial sphere on ground command with an accuracy of several seconds of arc. The torques for attitude control are produced primarily by inertia reaction wheels. Magnetic and cold gas inertia ~~dumping are employed~~ systems are utilized to unload the inertia wheels.

1 - 1 mi
2 - 1 au
3 - 1 au

~~to get rid of excess angular momentum.~~ The attitude control error signals are produced by a set of 6 star trackers and a computer, and by the telescopes themselves for the finest control. The attitude control system makes extensive use of the telemetry system, ground computers, and the command link to position the observatory for proper exposure of the experiment detectors. The central body is about 3 meters long and large enough to contain a 0.9 m diameter telescope. The overall weight of the OAO is about 1600 kgm.

The solar paddles are fixed with respect to the central body once the observatory is in orbit. For a given orientation of the longitudinal axis, the angle between the plane of the solar cells and the sun line is maximized by rotation of the observatory about this axis.

Many types of astronomical experiments will be flown on the OAO, including those designed to study the infrared, ultraviolet, X-ray, and gamma ray portions of the spectrum. Some of these will employ photon counting techniques to obtain very high sensitivities.

The first OAO is scheduled for launch by an Atlas Agena vehicle from Cape Canaveral in 1964 or 1965. Its orbit will be nearly circular, having a height of 760 km and an inclination of about 32 degrees.